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Meta-analyses of the determinants and outcomes of belief in climate change

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Recent growth in the number of studies examining belief in climate change is a positive development, but presents an ironic challenge in that it can be difficult for academics, practitioners and policy makers to keep pace. As a response to this challenge, we report on a meta-analysis of the correlates of belief in climate change. Twenty-seven variables were examined by synthesizing 25 polls and 171 academic studies across 56 nations. Two broad conclusions emerged. First, many intuitively appealing variables (such as education, sex, subjective knowledge, and experience of extreme weather events) were overshadowed in predictive power by values, ideologies, worldviews and political orientation. Second, climate change beliefs have only a small to moderate effect on the extent to which people are willing to act in climate-friendly ways. Implications for converting sceptics to the climate change cause—and for converting believers' intentions into action—are discussed.

A critical mass of people is sceptical that anthropogenic climate change is real, something that has long been identified as an obstacle to mitigation efforts[1–4]. It is not surprising, then, that there has been a concerted effort to examine the variables that are associated with acceptance of (and scepticism about) anthropogenic climate change. The insights associated with this research endeavour are important for a number of reasons, not least of which is that they lay the groundwork for future interventions.

The expansion of this research frontier is so quick that it can be difficult for academics, practitioners and policy makers to keep pace. Furthermore, relevant research has splintered across a large set of disciplines, including psychology, communication, sociology, political science, agriculture, climate science, and media studies. This is a positive development in that it allows for vibrant cross-pollination of theories, methods and assumptions. But it also creates challenges for consumers of the research, given that it is easy to miss relevant research in areas unrelated to one's own, and definitions and measures can vary substantially across disciplines, making it difficult to identify coherent messages.

In response to these challenges, the current paper reports the first meta-analytic examination of the demographic and psychological correlates of belief in climate change. The strength of the meta-analytic approach is its ability to rise above the churn of individual studies and to extract broad themes. As such, it provides a comprehensive overview of who endorses or opposes the reality of climate change and the main reasons they do so. Such an analysis draws on the energies of hundreds of individual climate researchers, but in a way that distils simple and digestible insights for academics, practitioners and policy makers.

Below we report the results of meta-analyses summarizing the relationship between climate change belief and 7 demographic variables (Fig. 1), 13 psychological variables that according to theory should be antecedents of climate change belief (Fig. 2), and 7 variables widely considered to be downstream consequences of climate change belief (Fig. 3). We acknowledge that most of the studies are correlational in nature, so although the distinction between antecedents and consequences are based on theoretical considerations, some relationships may be bidirectional. Statistics for the 27 meta-analyses are summarized in Table 1.

Results

Demographics and beliefs. The largest demographic correlate of climate change belief is political affiliation. People who intend to vote for more liberal political parties are more likely to believe in climate change than those who align themselves with relatively conservative political parties. The tendency for (conservative) Republicans to express more scepticism than (liberal) Democrats has long been identified within the US, and has been credited with contributing to a growing ideological gulf between sceptics and non-sceptics[5–8]. The current data further implicate political alignments in acceptance of climate change; its effect is roughly double the size of any other demographic variable.

The link between climate change beliefs and political ideology (that is, the extent to which people report being liberal or conservative, reported along a continuous scale and measured independently of voting intention) is also significant, but less strong. This suggests that acceptance of climate change is more aligned to specific identification with political parties than to underlying political ideologies.

Relatively small effects were found for the other demographic variables: age, education, income, race, and sex. People with stronger beliefs in climate change were younger, more educated, higher income, and more likely to be non-white and female, but these effects were muted. Although a 'conservative white male' profile has emerged of climate change sceptics in the US (ref. 9), our analysis of polls across multiple nations suggests that the 'conservative' part of that equation would seem to be more diagnostic than the 'white male' part.

Antecedents of beliefs. *Knowledge.* Early studies showed sceptics to have levels of scientific knowledge that were roughly equivalent to those of non-sceptics[10,11]. These studies, however, measured participants' subjective perception of their own expertise (subjective knowledge), leading some to argue that it would be more diagnostic to measure people's awareness of objectively verifiable facts

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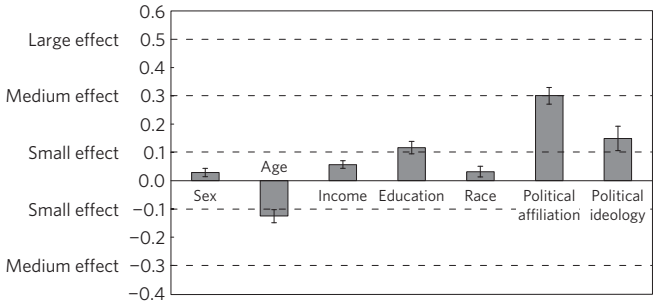

Figure 1 | Correlations between climate change belief and demographic variables. Sex is coded male = 0, female = 1; race was coded as 1 = White, 2 = Non-White. Higher scores on political affiliation and political ideology represent more 'left-wing' voting intentions and ideologies respectively. Error bars represent 95% confidence intervals.

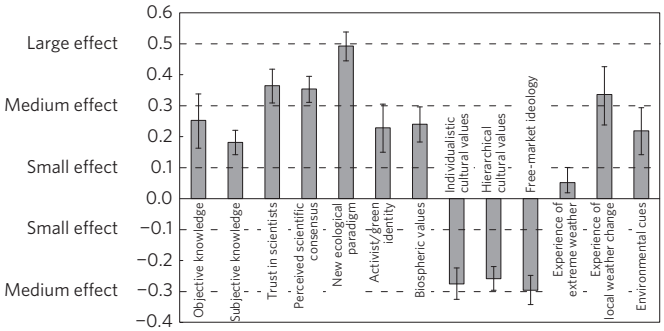

Figure 2 | Correlations between antecedent variables and climate change belief. Error bars represent 95% confidence intervals.

(objective knowledge)[12]. Our analysis suggests that belief in climate change is stronger the greater people's subjective and objective knowledge, but consistent with theorists' intuitions the association is stronger for objective knowledge than for subjective knowledge (see Fig. 2). It should be noted, however, that these main effects may be qualified by a moderated effect: research in the US using representative samples suggests that the link between (subjective) knowledge and belief is strongly positive among Democrats and Independents, but negligible among Republicans[11,13]. Such observations reinforce arguments that knowledge-related variables may be shaped by, or trumped by, ideological factors[14–17].

Beliefs about science. In the face of very high complexity, people are prone to make judgements using cognitive heuristics, or 'rules of thumb', rather than systematically reviewing evidence. Two interrelated heuristics have been implicated in climate change belief: a source heuristic ('scientists are trustworthy so the scientific orthodoxy must be true')[11] and a consensus heuristic ('there is scientific consensus around climate change, and consensus implies correctness')[18–20]. As can be seen in Fig. 2, belief in climate change was stronger the more people endorsed these heuristics, representing the second- and third-largest psychological predictors of climate change belief.

Concern for the environment. It makes intuitive sense that people concerned about the environment's vulnerability will be more attentive to the dangers of climate change, and may use a precautionary principle in weighing up the levels of evidence ('if there is a chance that climate change is real then it is enough of a reason to act'). One of the most widely used constructs in the environmental psychology literature is the New Ecological Paradigm (NEP; ref. 21), a scale that is weighted heavily with items about the fragility of the environment and the importance of minimizing humanity's impact on it. Although the scale does not mention climate change, belief in climate change tends to be stronger the higher people endorse the NEP. Indeed, this relationship was the strongest of all the variables.

We also identified 16 studies that measured whether people have a 'green' or activist identity with regard to the environment. Although such an identity may reflect many things, it can be interpreted as a reflection of what happens when concern for the environment becomes embedded as an important social category in one's self-concept. Unsurprisingly, the stronger people's green identity the stronger their acceptance of climate change. The fact that the positive relationship was relatively weak may partly reflect the fact that some people perceive stigma around activist identities, and so would rather construe their concern in terms of their personal values rather than as a social identity.

Values and ideologies. There is a vast body of research examining how social attitudes are influenced by underlying ideologies, worldviews and values, and increasingly this approach has been applied to understanding climate change beliefs. Drawing on Schwartz's[22] theory of universal values, Stern and colleagues[23] identified a set of specifically biospheric values that relate to protecting the environment. Figure 2 confirms that placing a high importance on the natural environment is associated with believing climate change is real, showing a small to medium effect size.

Another influential theory is Cultural Cognition (adapted from Douglas's Cultural Theory)[24], which argues that people's perceptions of risk are influenced by their concept of how society should be structured, and that this conceptualization leads them to uphold specific cultural values[16,25]. For example, people who subscribe to relatively individualistic and hierarchical values are more inclined to value elites and the status quo, and so are motivated to disbelieve that industry poses a risk to the environment. In contrast, people who subscribe to relatively egalitarian and communitarian values are more likely to have a moral suspicion of industry, and so are motivated to embrace the risk that industry presents to the environment. These propositions are supported by the data: belief in climate change is lower the more people adopt hierarchical and individualistic cultural values.

Another ideology that has been implicated in climate change beliefs is free-market ideology, which maintains that the forces of supply and demand should be freed from interventions by regulating authorities. Some scholars have argued that free-market ideologies underpin a range of conspiratorial and sceptical beliefs about science, including climate change scepticism[26,27]. Our analysis of studies that measure both free-market ideology and climate change beliefs lends support for this notion.

Situational cues. A growing research tradition has examined whether people's climate change beliefs are sensitive to direct experiences of weather and other proximal environmental cues. Since researchers first pointed to the fact that British people affected by floods were more likely to believe in climate change[28], there is now a critical mass of studies to gauge whether there is a more general link between climate change belief and experience of extreme weather events. Although significant, the relationship is negligible in size.

Other studies have focused on whether people who experience changes in the local weather over time are more likely to believe in climate change. Some of these studies use objective weather data (for example, fluctuations in temperatures over the previous year) whereas others measure perceptions of such changes. When gathering these data we were careful to exclude items that used the term 'climate change' or 'change in the climate' as part of the measure, to avoid circularity between this predictor and our criterion variable. However, some conceptual overlap is unavoidable in operationalizing this construct, and it cannot be ruled out that

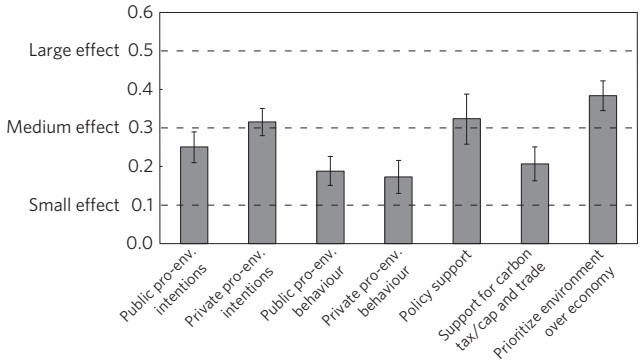

Figure 3 | Correlations between climate change belief and outcome variables. Error bars represent 95% confidence intervals.

this would have inflated the relatively large positive correlation with climate change belief.

Finally, a set of experimental studies have drawn on the social psychological literature on subliminal priming to examine whether priming people with environmental cues of climate change (for example, turning up the heat in the laboratory; placing dead trees around participants) has an effect on their belief in climate change. The observed link between these inductions and climate change belief are significant, perhaps surprisingly so given that their impact is unconscious.

Consequences of beliefs. A presumed outcome of believing that (anthropogenic) climate change is real is that people will be motivated to engage in pro-environmental behaviours that help mitigate climate change. Our coding distinguished between subjective ratings of future intentions and ratings of actual behaviours. As can be seen in Fig. 3, the more people believe in climate change the stronger their pro-environmental intentions and behaviours, but the relationship was stronger for intentions than for behaviours. This is not surprising given that intentions are less compromised by practical reality constraints than are behaviours, and so the relationship between beliefs and intentions is more 'pure'.

In our coding we also distinguished between public-sphere and private-sphere pro-environmental behaviours and intentions, using a taxonomy by Stern[29]. Examples of public-sphere acts include petitioning on environmental issues and contributing to environmental organizations. Examples of private-sphere acts include individual energy reduction strategies and recycling. Interestingly, the gulf between intentions and behaviours observed earlier was more pronounced in the private-sphere than the public-sphere behaviours. This may reflect the fact that some of the public-sphere behaviours may not be as influenced by reality constraints as private-sphere behaviours (for example, whether one takes public transport may depend on transport availability).

In our review we noted a critical mass of studies that focused on support for public policies that help mitigate against climate change. Within this broad category we identified three categories of studies which varied in how concretely the policy measures were described. At the most abstract level were studies asking people to reflect on the tradeoff between the environment and the economy. Perhaps unsurprisingly, higher willingness to prioritize the environment over the economy was associated with higher acceptance of climate change. Other studies focused on support for specific public policies such as promoting alternative energies or creating green policies within organizations ('policy support' in Fig. 3). Here, the link with climate change beliefs was also significant and positive, but less so than when studies asked about the principle of prioritizing the environment over the economy. We also identified 31 studies that measured acceptance of climate change and support for mitigation policies that place a price on carbon (carbon tax or cap and trade); enough so that we analysed these studies as a discrete category. The positive link is intuitive, but only small to medium in size. It is noteworthy that the link between these various indices of policy support and climate change beliefs get smaller the more specific and concrete the measure of policy support, and the more the measure implies personal cost on behalf of the respondent.

Moderation analyses

Table 1 reveals reasonably high levels of variation in the strength of effects of individual studies within our meta-analyses that cannot be attributed to random error. To help identify why this variability exists, we conducted moderation analyses designed to test whether the strength of effects systematically differed across various conditions. Specifically, we performed separate meta-regressions examining three types of moderators: the type of climate change measure used; whether the sample was from the USA; and the extent of climate change contributions in the country where the sample was drawn.

Type of measure. Effect sizes for six constructs were significantly moderated by whether climate change was measured with reference to causes (that is, anthropogenic climate change; $k=40$ studies) or more generally ($k=131$). The pattern was mixed: The effects of environmental cues ($\beta=0.50$, $df=14$, $p=0.022$) and subjective knowledge ($\beta=0.84$, $df=32$, $p<0.001$) were stronger when climate change was measured without reference to being anthropogenic. In contrast, the effects of public pro-environmental behaviour ($\beta=-0.44$, $df=22$, $p=0.026$), public pro-environmental intentions ($\beta=-0.47$, $df=43$, $p=0.002$), private pro-environmental intentions ($\beta=-0.49$, $df=64$, $p<0.001$), and support for a carbon tax ($\beta=-0.38$, $df=30$, $p=0.003$) were stronger when anthropogenic climate change was measured. This last cluster of effects makes sense: individual action to mitigate climate change is more likely when one believes that climate change is not only happening, but is caused by human activity. Measures of anthropogenic climate change are more likely to pick up on this nuance.

Nationality of sample. Moderation analysis compared US studies (48% of the sample) with non-US studies. Three relationships were stronger in the US samples: public pro-environmental intentions ($\beta=-0.41$, $df=43$, $p=0.008$), support for a carbon tax ($\beta=-0.62$, $df=30$, $p<0.001$), and willingness to prioritize the environment over the economy ($\beta=-0.53$, $df=19$, $p=0.003$). Two relationships were stronger in the non-US samples: subjective knowledge ($\beta=0.43$, $df=32$, $p=0.001$), and free-market ideology ($\beta=0.47$, $df=29$, $p=0.011$)

Climate change contributions. It is plausible that climate change beliefs could be linked to the extent to which a country was a significant contributor to climate change. We ran moderation analyses examining whether the strength of effects across studies was correlated with the climate change subscale of the Environmental Performance Index[30]. Only one significant effect emerged: the better the environmental performance of the sample nation in terms of emissions and renewables, the stronger was the relationship between climate change belief and objective knowledge ($\beta=0.43$, $df=16$, $p=0.007$), suggesting that national-level performance might trickle down to individual level knowledge and understanding (or vice versa).

Implications

One message from the data is that traditional societal faultlines of gender, age, sex, race, and income seem to be of little relevance in determining levels of climate change scepticism. This is not

Table 1 | Data summary.

	Correlation	Q (total heterogeneity)	k (number of studies)	I^2	T^2
Demographics					
Sex	0.029	59.42	25	59.61	0.001
Age	−0.125	178.38	25	86.55	0.003
Income	0.057	21.03	23	0.00	0.000
Education	0.117	109.80	22	80.87	0.002
Race	0.032	8.08	12	0.00	0.000
Political affiliation	0.301	68.01	20	72.06	0.004
Political ideology	0.149	338.20	30	91.43	0.015
Antecedents of climate change beliefs					
Objective knowledge	0.253	383.28	17	95.83	0.033
Subjective knowledge	0.182	459.36	33	93.03	0.012
Trust in scientists	0.365	359.51	23	93.88	0.019
Perceived scientific consensus	0.349	427.92	30	93.22	0.016
New ecological paradigm	0.493	547.63	38	93.24	0.035
Activist/green identity	0.229	458.95	16	96.73	0.026
Biospheric values	0.252	46.52	6	89.25	0.009
Individualistic cultural values	−0.275	150.63	14	91.37	0.010
Hierarchical cultural values	−0.258	102.94	16	85.43	0.006
Free-market ideology	−0.296	242.43	30	88.04	0.018
Experience of extreme weather	0.052	28.44	9	71.87	0.002
Experience of local weather change	0.336	446.91	17	96.42	0.042
Environmental cues	0.219	97.56	15	85.65	0.018
Consequences of climate change beliefs					
Public pro-environmental intentions	0.251	751.13	44	94.28	0.019
Private pro-environmental intentions	0.316	1,105.55	65	94.21	0.023
Public pro-environmental behaviour	0.188	155.86	23	85.88	0.007
Private pro-environmental behaviour	0.173	857.14	38	95.68	0.018
Policy support	0.324	681.48	25	96.48	0.030
Support for carbon tax/cap and trade	0.207	290.47	31	89.67	0.014
Willingness to prioritize environment over economy	0.384	180.88	20	89.50	0.009

All correlations are pooled effects, and are significant at $p < 0.005$. Q-statistics were derived using a random-effects model, and were significant at $p < 0.01$ for every variable except income and race. Demographic data were based on polls from five research organizations. All five measured sex and age. Education was measured by Essential, Pew, Eurobarometer, and UK Department of Energy; income was measured by Essential, Pew, and UK Department of Energy; political affiliation was measured by Pew and Essential; political ideology was measured by Pew and ISSP; and race was measured by Pew, coded as 1 = White, 2 = Non-White. Q = total variance, I^2 = proportion of variability due to heterogeneity between studies rather than sampling error, T^2 = between-study variance.

to say there are not important lessons that can be extracted from examining these demographics, and these variables can interact with psychological variables in meaningful ways. But these demographics shared only small relationships with climate change belief, as did education, (subjective) knowledge, and experience with extreme weather events.

Indeed, these intuitively appealing determinants of climate change belief were overshadowed in predictive power by values, ideologies and political affiliation. Consistent with the reasoning of many theorists in this area, the data suggest that 'evidence' around climate change is searched, remembered, and assimilated in a way that dovetails with people's own political loyalties and their worldviews. For some, this may lead to a disregard for (or misunderstanding of) the scientific consensus around climate change. In the face of this, one can argue that there are limits to the extent to which sceptics can be 'converted' through facts and explication alone, and it is equally implausible that climate scientists can change people's underlying values and political allegiances. Instead, some have argued that pro-environmental behaviours can be coaxed out of people by working with their ideologies rather than against them; for example by framing pro-environmental action as a form of patriotism[31] or as an investment in 'green' technologies[32,33].

In terms of the consequences, a salient message from the data is that climate change beliefs have only a modest impact on the extent to which people are willing to act in climate-friendly ways. When phrased in abstract ways (for example, the willingness to prioritize the environment over the economy) the link with climate change beliefs is relatively strong. But when more specific policies are probed the relationship shrinks, and when policy support is specifically measured with respect to putting a price on carbon it shrinks again. A similar shrinkage occurs when one compares intentions and behaviours: belief in climate change has a solid relationship with the extent to which people aspire to behave in climate-friendly ways, but a small-to-moderate relationship with the extent to which people 'walk the talk'.

Overall, these findings show the benefit of moving beyond the question of 'who' disbelieves that climate change is real (for example, conservatives) to the psychological factors that help explain 'why' people hold their views about climate change. The findings offer some hope, because psychological factors are more susceptible to targeted interventions than are demographic constructs. Certainly, the challenge remains great, as climate change beliefs are influenced by distal psychological and political beliefs that shape people's assimilation of 'the facts'. Yet, by showing which constructs are most systematically and strongly associated with climate change beliefs across studies, we hope to provide the research community with the best information about how to mobilize and target their efforts.

Methods

Methods and any associated references are available in the online version of the paper.

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Author contributions

M.J.H. conceived and designed the meta-analyses, and led the writing. E.A.H. gathered and analysed the data, and co-wrote the paper. P.G.B. and K.S.F. contributed expertise in terms of materials and analysis tools, contributed to the design of the meta-analysis, and co-wrote the paper.

Additional information

Supplementary information is available in the online version of the paper. Reprints and permissions information is available online at www.nature.com/reprints. Correspondence and requests for materials should be addressed to M.J.H.

Competing financial interests

The authors declare no competing financial interests.

Methods

Choosing variables. In deciding which correlates of climate change belief to include in the meta-analyses we were guided by two criteria. One criterion was whether there was a critical mass of studies to allow for reliable conclusions to be drawn. With this in mind, all the variables selected for the meta-analyses were assessed in five or more data sets. The second criterion was whether the variable was theoretically relevant to climate change beliefs, but conceptually independent of believing climate change is real. Some widely researched variables pre-suppose that the participant believes in climate change (for example, perceptions of risk presented by climate change; perceptions of efficacy about mitigating climate change) and to avoid circularity we did not examine these variables. Readers interested in finding out more about these variables can draw on recent reviews[34,35].

Sampling data sets. When examining the relationship between demographic variables and climate change beliefs it is important to draw on data sets that use representative, stratified samples. Although there is academic literature that also uses these sampling techniques, we decided to base our observations on data by established polling companies and government agencies whose job it is to conduct large-scale, accurate polling of the broad population. These data are based on five major research organizations that measured belief in climate change: Pew Research (12 polls conducted in the US 2006–2013), UK Department of Energy and Climate Change (three polls conducted among British participants 2012–2014), International Social Survey Programme: Environment III (ISSP, conducted across 32 countries in 2010); Essential Research (eight polls conducted among Australians 2010–2014), and Eurobarometer (conducted within 30 European nations by the European Commission in 2009).

For the remaining constructs—the thirteen psychological antecedents and seven consequences—we sampled from papers published in academic outlets on or before April 2014. We sampled any studies that (quantitatively) measured both belief in climate change and one of the 20 correlates included in the analysis. Most of these data sets were collected by academics for the purpose of their study, but some involved secondary analyses of larger data sets collected by research companies or government agencies. To prevent the same data set and statistics being incorporated multiple times, we excluded studies that reported statistics for the same variables using the same data set. Information about the search strategy—with details about how the final sample of 171 studies was identified—are provided in the PRISMA diagram in the Supplementary Methods. A summary of all the studies sampled, with a complete bibliography, can also be found in Supplementary Methods.

Analytic strategy. Meta-analyses were conducted using Comprehensive Meta-Analysis software[36]. Correlation coefficients were converted to Z-scores and then back-transformed for reporting. Because zero-order correlations (transformed) were used, we applied the standard weighting ($n-3$). We used random-effects meta-analysis to identify the average correlations across studies, weighted by the size of the samples. It should be noted that we examined each construct separately using separate random-effects meta-analyses, so direct statistical comparisons between effect sizes across constructs were not made.

In addition to average effects, indicators of variation across samples are also shown in Table 1. The Q-statistics whether the amount of variation in effect sizes across studies occurs by chance. The I^2 statistic shows the proportion of this variation attributed to 'true' differences in effect sizes across studies (with the remaining variation attributable to random error), with 0.25 indicating a low proportion, 0.50 a moderate proportion, and 0.75 a high proportion[36]. We include T^2 in the table for reference purposes as it represents the actual variance in true effects across studies. Meta-regressions were performed separately for each variable showing moderate/high proportions of 'true' cross study variation, using a meta-regression macro for the SPSS statistical program (http://mason.gmu.edu/~dwilsonb/ma.html), with a random-effects model and 'method of moments' estimation.

References

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